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BRAIN-CENTERED HAZARDS: RISKS & REMEDIES

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Knowing that risk is created by exposure to hazards, all members of the workforce have been enlisted to become "hazard recognizers." Front-line workers and leaders alike are taught to observe their work environments for physical, technological, and behavioral elements that can cause or contribute to personal injuries and/or organizational accidents. The purpose of hazard identification is to determine the right hierarchy of controls, beginning with elimination of the hazard or substitution of materials and processes. A great deal of progress in personal and process safety has been made through the effective identification and control of these hazards. But what if the potential hazards and associated safety and business risks are housed in the human brain? And, what if these brain-centered hazards are exacerbated by the fact that critical organizational elements—including work environments, technological interfaces, operating procedures, work schedules and even work cultures—are not aligned with how the human brain actually works?

This paper outlines some of the brain-centered hazards identified by applying recent neuroscience research to our modern workplaces. Specifically, three key lessons from neuroscience are explored in detail so leaders can be alerted to the types of risks lurking in every one of their worksites. Then, this paper introduces a hazard mitigation approach that enables leaders to reduce exposures to these newly-understood hazards. What is most crucial for leaders to understand is that, left unattended, brain-centered hazards can create high-consequence exposures as serious as toxic chemicals or loss of controls. In fact, some of our most serious organizational accidents have involved brain-centered hazards typically identified as "human errors."

THE FAST BRAIN IS IN CHARGE

Neuroscientists have confirmed in recent years that different "factions" in the human brain compete to control the single output channel of human behavior. Of most importance is the "dual-process" system of the Fast Brain and Slow Brain. The former is housed primarily in the limbic system or Paleomammalian part of the human brain, and produces automatic, pre-conscious, reactive, habitual, and emotion-based actions. The latter is housed primarily in the brain's pre-frontal cortex, its "executive" center. The Slow Brain operates with conscious cognition, producing analytical, reasoned, reflective, and thoughtful actions. This conscious part of the brain is the human defense system against impulsive emotion-laden reactions that can put a person at risk and cause him or

her (and others) harm. And, the problem identification, analysis, and troubleshooting capabilities of the Slow Brain often are a critical line of defense against all types of hazards in the work environment or work processes. Unfortunately, neuroscientists now tell us that the Slow Brain is not in charge much of the time. That is, our actions are directed primarily by the Fast Brain, and therefore, are often pre-conscious, habitual, and/or reactive in nature.

The Fast Brain is the primary controller because it is both speedier and more energy-efficient. The human brain uses more energy than any other body organ—upwards of 20% or more of the body's available energy—even though it constitutes only 2% of human body weight. For this reason, the human brain has evolved to rely on its fast processor as often as possible, even "live wiring" its neuronal pathways to facilitate automatic, reflexive behavior without us consciously choosing to do so. Take driving a car as an example. Most adults over 25 years of age have practiced driving long enough that they can do it "without thinking," meaning without consciously going through all of the steps of procedure involved in driving a car. Similarly, in the workplace, jobs involving routine and repetitive tasks are at risk of being performed "without thinking"; that is, they are performed with the Fast Brain in charge, not the analytical, reflective Slow Brain. And, as with driving, most of the time such routine tasks will be done safely and productively. Yet, performing a job task from the Fast Brain creates several brain-centered hazards, including failure to consciously complete every step of procedure every time a routine job task is performed and failure to double check our actions. Conscious cognition, housed in the Slow Brain, has to be activated in order for the self-analytical part of the brain to perform self-checks on our work.

THE FAST BRAIN SEES IN "SKETCH MODE"

One of the ways in which the Fast Brain is fast is in how it processes visual information, which is 90% of the information received by the human brain. In just 4/10 of a second, the human subcortical vision system evaluates the external environment and begins to direct emotional and behavioral responses. Specifically, the subcortical system located in the thalamus—part of the Fast Brain—processes color, shape, and movement information and creates a "sketch" of a visual object, similar to a caricaturist drawing a person's face. If the anterior cingulate cortex (ACC) that connects the Fast Brain and Slow Brain does not perceive any discrepancies between the "sketch" and its experience-driven expectations of the external environment, action is taken without ever engaging the thinking or cognitive parts of the human brain.

Looking in Fast Brain mode is sufficient if your survival depends on scanning the physical environment for one or two predators, like large cats on the African savannah. In the complex work environments of today, however, such generalized looking typically fails to uncover key situational clues like weak signals for upsets in the making. Notably, without seeing and understanding weak signals, preventive action cannot be taken. That's why failure to detect critical changes in the work environment and/or changes in technological conditions surrounding job tasks are among the most serious brain-centered hazards that result from Fast Brain modes of scanning and sketch-seeing. Conscious cognition, housed in the Slow Brain, has to be activated for humans to fully see and accurately analyze and interpret all aspects of the external environment. Unfortunately, it takes half a second just to activate our cognitive capabilities, and by that time, habitual or impulsive action directed by the Fast Brain already has commenced. Activation of the Slow Brain has to precede critical task performance in order to ensure active situational awareness and reliable task execution.

FATIGUE IMPAIRS BRAIN PERFORMANCE

Recent evidence from functional MRIs (fMRIs) has definitively proven that brain fatigue causes performance impairment. Fatigue of the brain or cognitive fatigue results from insufficient Delta-wave or deep sleep in either the last 24 hours (acute fatigue) or the past 7 days (cumulative fatigue). And such deprivation of deep sleep in even a single 24-hour period has been proven to cause measurable impairment of key performance capabilities. Specifically, fMRI studies visually demonstrate that sleep deprivation significantly degrades the following types of Slow Brain functions:

- Attention to detail
- Impulse and risk inhibition
- Accurate memory recall
- Problem analysis
- Conceptual thinking
- Planning ahead
- Decision making

In addition, reaction times are slowed, irritability is heightened, and judgment is impaired when a person is in a state of sleep deprivation and associated cognitive fatigue. From a safety and reliability per-spective, numerous brain-centered hazards are created when one or more employees are operating with moderate to severecognitive fatigue, whether acute or cumulative in nature. For one, employees cannot effectively "think ahead" or conceptualize solutions for problems that start to emerge. The thinking, reasoning and troubleshooting capabilities of the Slow Brain—the capabilities that serve as a person's best defenses from harm at work—are not functioning effectively (or at all) when sleep-deprived. In addition, humans lose their self-awareness capabilities when cognitively fatigued, resulting in the inability to assess how impaired they actually are. Without the Slow Brain in operation, conscious self-reflection and self-monitoring just don't happen. This latter hazard is especially dangerous when combined with the elevated risk-taking characteristic of sleep-deprived people. Given that fatigue is experienced by 39% to 67% of the workforce worldwide every day, it is not surprising that cognitive fatigue is viewed as the number one brain-centered hazard in modern work-places. In fact, the National Transportation Safety Board

in the U.S. has designated "Addressing Human Fatigue" as the first item on its Most Wanted List for ensuring safe roads and safe transport. And, the U.S. Nuclear Regulatory Commission has cited workplace fatigue as a hazard to be managed so that "personnel are fit to safely and competently perform their duties."

WHAT CAN BE DONE?

Neuroscience has provided new knowledge and understanding about potential hazards originating in how the human brain works. But what should leaders do with this new science? Reflecting on the hierarchy of controls for addressing workplace hazards, it is clear that companies cannot eliminate potential brain-centered hazards altogether as that would require the elimination of all humans from the business. Even substitutions typically are not a viable approach, especially in process industries or labor-intensive industries where auto-mation cannot fully replace humans. Rather, what must be done in all companies where humans perform safety-critical job tasks is the implementation of new systemic layers of defense that are designed to drive Brain-Centric Reliability™ into all human actions. More specifically, leaders have to re-think and re-design their worksites, instituting organizational and team structures, systems, practices, and procedures that are brain-aligned (see Figure 1). The effective activation and essential engagement of employees' capabilities for conscious cognition must be supported at the organizational, team, and individual levels of the enterprise. For this reason, everything from the organizational culture and leadership messaging to job designs, workforce training, work schedules, team dynamics, operating procedures, human machine interfaces, and even incident investigations need to be revamped to align with new brain science.

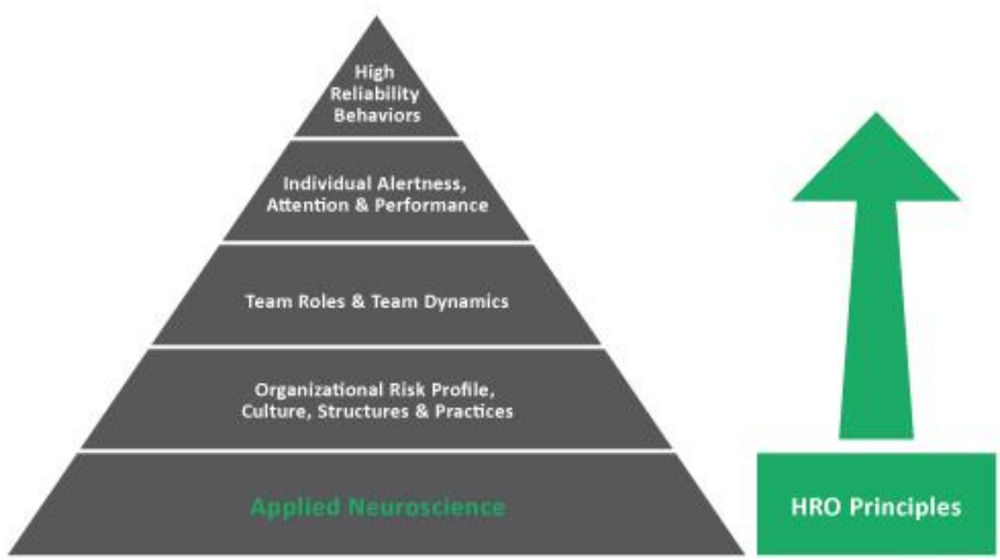

Figure 1 SAFR SYSTEM FOR BRAIN-CENTRIC RELIABILITY™

To illustrate this concept of brain-aligned organizational elements, consider two important facets of every workplace: the organizational culture and standard operating procedures (SOPs).

Culture

With respect to culture, it is now recognized that leaders' messaging and modeling (what they say and do) set organizational culture and corresponding member be-haviors. When leaders transmit messages of urgency to their workforce, they probably don't realize that such time pressures actually diminish Slow Brain engage-ment. The ACC in the neocortex picks up urgency messaging as a stressor, and engages the Fast Brain to deliver a finished task as quickly as possible. But a finished task is not the same as error-free performance. Facilitating high human reliability requires different cultural messaging from leaders. Specifically, the human brain needs to be primed with messages of Right-First-Time Reliability, such as: You always have the time to do the job right, and, Take your time so you do the task right the first time. This type of reliability-centered messaging signals the human brain to "think through" job tasks, focusing on execution of correct actions rather than the speed of action.

Authored By:	Loss of Burners in 87F-103	Doc No.: **105.4483** Rev No: 3
Doc Custodian: CX-4 Process Specialist		**Operating Guideline**
Approved By: Area Team		
Date Approved: 10-14-2013	Next Annual Certification Date: 10-14-2014	Effective Date: 10-14-2013

Step 1.0	**Description**
NOTE: If at anytime during the process of relighting the Furnace problems are experienced that cause a significant delay, notify PDU of a possible gasoil wash.	
1.1	Verify that the Furnace has shutdown and pilots are out.
1.2	Reduce the Unit Charge to Minimum immediately. a. Increase the external recycle to reduce the fresh feed. b. Block in the gas oil and distillate products.
1.3	Proceed with the Furnace relighting process.

Chart 1 **ERROR-PRONE SAMPLE OF STANDARD OPERATING PROCEDURE**

Standard Operating Procedures

In terms of SOPs, many leaders are deeply frustrated
by incident investigations that conclude with the finding: "Failure to follow procedures." Yet, how many leaders ask whether SOPs are brain-aligned, meaning are they written for ease of usage by the human brain or do they require second-guessing and interpretation by the users? If interpretation is required, the probability of incorrect actions increases significantly. Chart 1 below contains a verbatim excerpt from a Loss of Burner SOP in a U.S. oil refinery. This SOP covers a highly safety-critical task, yet it is extremely unclear in several respects. For example, what is meant by a "significant delay" in the important NOTE section of this SOP? Is it 10 minutes or 60 minutes? In Step 1.1, how does an employee verify that the "Furnace has shut down and pilots are out"? In Step 1.2, what is the "Minimum" to which the Unit charge is to be reduced "immediately"? In Step 3, how is the Furnace relit safely? This real example of an SOP design relies on the memory of employees for reliable procedural execution when, in fact, human memory is itself a brain-centric hazard. If error-free actions are required, as they are in all safety-critical tasks, then brain-aligned SOPs must be provided to the workforce. Every step of procedure must begin with a clear action verb. Sufficient white space and visual images must be deployed. These and other brain-aligned SOP design principles can make the difference between error-prone task execution and high human performance reliability.

STEPS FOR SUCCESS

In light of recent neuroscience findings, companies cannot continue with operations-as-usual that leave brain-centered hazards unidentified or unaddressed. Instead, new brain-aligned operational and safety defenses must be instituted to reduce exposures to these hazards. Generating high human reliability in task performance necessitates the use of Applied Neuroscience combined with High Reliability Organization (HRO) Principles, as promoted by the SAFR

SYSTEM for Brain-Centric Reliability™. But, where to begin? Achieving sustainable results in the most efficient manner requires a company-configured Reliability Roadmap. This Roadmap is best crafted with data from a comprehensive SAFR Operations™ Analysis, which documents brain-centered hazards and associated weaknesses in a company's operational and safety systems for risk and reliability management. The data-driven selection of brain-aligned solutions for the organizational, team and individual levels of the enterprise enables company leaders to deliver deep and lasting human performance reliability.

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